

ITS Tools and Facilities

Advanced Antenna Testbed

The advanced antenna testbed (ATB) is a multi-channel test facility based on ITS digital sampling channel probe technology. The system can simultaneously characterize eight wideband radio channels or antenna elements. The system can be configured for multiple channel recordings at one frequency or at multiple frequencies. When configured at one frequency, orthogonal pseudo noise codes can be transmitted from multiple antenna elements. The table below summarizes the range of permissible values for the ITS channel sounding system, as well as giving an example of a measurement system configured for 2.3 GHz and 10 Mb/s operation.

Configurable Testbed Parameters

Parameter	3G Example	ITS System
Receiver Channels	8	1-8 (expandable to 16)
Carrier Frequency	2.3 GHz	.45 – 6 GHz
Bit Rate	10 Mb/s	.1 – 50 Mb/s
Resolution	100 ns	20 ns – 10 μ s
Code Type	Maximal Length	Programmable
Code Length	511 bits	Programmable
Acquisition Mode	Burst	Continuous or Burst
Positioning	GPS/Dead Reckoning	GPS/Dead Reckoning
Transmitters	16	Multiple
Data Processing	Post	Post

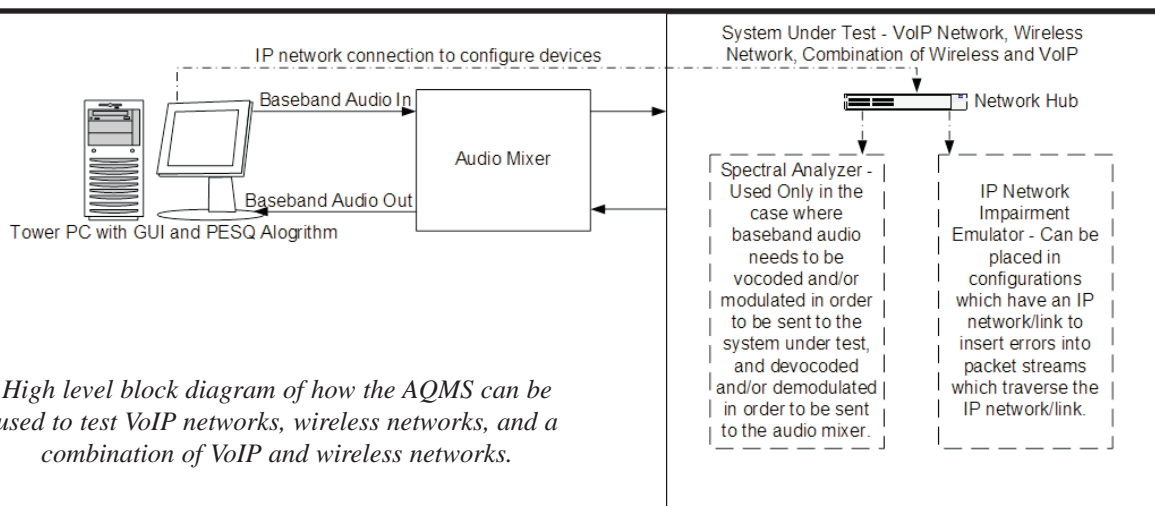
The ATB provides common reference sites for evaluating next-generation antenna systems. Data from multiple channels can be used to test the diversity gain resulting from various signal combining algorithms. Digital beam forming and multiple input, multiple output (MIMO) techniques may also

be examined by simultaneous digitization of signals from multiple antenna elements. Sites in Boulder and Denver, Colorado, serve as known environments for evaluating 3G components and systems. Alternately, the ATB system may be van-mounted for site mapping studies at any required location.

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Audio Quality Measurement System (AQMS)

The Audio Quality Measurement System (AQMS) is a tool for evaluating the voice quality of Voice over IP (VoIP) systems, wireless systems, and combination systems consisting of both VoIP and wireless infrastructure. Instead of using an actual panel of individuals to score the audio quality of a particular speech file, an audio quality estimator algorithm, known as PESQ (Perceptual Evaluation of Speech Quality), can be used to provide an estimated mean opinion score (EMOS). The scores are assigned on a scale of 1–5, with 1 being the worst and 5 being the best. The extensive research performed by Stephen Voran in the Audio Quality Research Laboratory acted as a springboard for the development of the AQMS. A block diagram of the AQMS is shown below. The core components of the system are the custom graphical user interface (GUI), the PESQ algorithm, and an audio mixer. The spectral analyzer and the network impairment emulator can be thought of as auxiliary components of the AQMS.



High level block diagram of how the AQMS can be used to test VoIP networks, wireless networks, and a combination of VoIP and wireless networks.

The system works by playing a group of 40 Harvard phonetically balanced speech files into the system under test (SUT). The speech files are started through the GUI. Before playing the speech files into the system, the user can invoke the documentation feature of the GUI interface to record the audio levels of the mixer, the IP impairment levels of the network impairment emulator, the spectrum analyzer's settings, the type of equipment under test, and the configuration of the equipment under test. The GUI also provides the ability to remotely interface to and configure the spectral analyzer and the network emulator before the 40 speech files are played into the SUT. The final feature of the AQMS is that it generates a two-dimensional plot where the x-axis (range is fixed from 1 to 40) represents the speech files and the y-axis represents EMOS. This two-dimensional plot contains other important information such as the median EMOS, average EMOS, the IP impairments selected, and their respective levels.

So far this system has been used to evaluate the voice quality of a Project 25 VoIP combination system which is comprised of two ultra/very high frequency (UHF/VHF) repeaters which have the capability to transmit over IP links. It has also been used to evaluate the voice quality of VoIP-capable telephones that require the use of session initiated protocol (SIP) or H.323 to make a telephone call. This test setup supplements the acoustically coupled audio test setup discussed by D.J. Atkinson on pp. 22-23 of this report.

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Audio-Visual Laboratories

The ITS Audio-Visual Laboratories offer a wide range of audio and video recording, storage, processing, reproduction, objective quality assessment, and subjective testing capabilities. These capabilities in turn support the development and verification of new quality estimation techniques for compressed digital audio and video, the development of novel subjective testing techniques for audio and video signals, and the development of new coding algorithms.

Laboratory equipment supports standard-definition (SD) and high-definition (HD) video signals, as well as monophonic, stereophonic, and 5.1 channel audio streams. Signals are acquired with high-quality microphones and cameras. Recording and playback

devices include studio-quality analog and digital video tape recorders with two to eight audio channels, digital audio tape machines, CD players, and analog audio cassette machines. These systems are augmented with several computer-based digital audio and video systems and a set of high quality Analog-to-Digital and Digital-to-Analog converters. Analog audio mixing, filtering, and equalizing equipment is available. An array of digital audio and video encoders and decoders are available, as well as an HDTV modulator and demodulators. Analog and digital audio and video routing switches and patch panels allow for nearly arbitrary interconnections between the various pieces of equipment. Reproduced signals are presented through studio quality video monitors, monitor loudspeakers, headphones, or handsets.

Two separate rooms with controlled acoustic and visual environments are available for the subjective testing of audio and video signals. These environments are specified in International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) Recommendation P.800 and ITU-R Recommendation BT.500 respectively. These specifications address background noise levels, wall colors, light levels, room dimensions, and other properties. A third room is used exclusively for the presentation of HD video signals.

Finally, the labs feature an array of audio and video signal generators and analyzers to support laboratory measurement and calibration activities. Computers play a key role in laboratory operations. Two systems offer the ability to record and play back uncompressed digital audio bit-streams together with synchronized SD video bit-streams that conform to International Telecommunication Union — Radio-communication Sector (ITU-R) Recommendation BT.601 (i.e., Society of Motion Picture and Television Engineers SMPTE 259M/272M specification) and synchronized digital audio streams to and from a high-speed workstation with over 1 TB of hard disk storage. Another computer-based system can record and play back uncompressed HD audio and video bit-streams in accordance with the SMPTE 292M format. Much audio and video processing is performed on a cluster of four high-performance workstations, supported by 12 TB of disk storage.

Lab activities include objective estimation of audio and video quality, and subjective testing of audio and video quality. Random access digital audio video playback systems coupled with discrete-time

and continuous-time electronic data entry systems greatly facilitate many of the subjective testing activities. Because multiple subjective testing rooms are available, the laboratory can support conversation, teleconferencing, and video teleconferencing tests as well as viewing and listening tests. Objective video quality estimation software, written in C++ and MATLAB, processes video signals in accordance with American National Standards Institute (ANSI) T1.801.03-2003, resulting in estimates of video quality that show good correlation with subjective test results. Several different objective speech and audio quality estimation algorithms are available, including those defined in ANSI T1.518, ITU-T Recommendation P.862, and ITU-R Recommendation BS.1387. The labs support both batch-mode and real-time objective quality estimation.

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Digital Sampling Channel Probe

The digital sampling channel probe (DSCP), designed and patented at ITS, is used to characterize the wideband propagation characteristics of the radio communication channel. The probe, consisting of a transmitter, receiver, and data acquisition system, is used to make complex impulse response measurements. The DSCP digitizes a received pseudo-noise signal at an intermediate frequency (IF) and then post processes the data. The digital system is capable of collecting impulse response data on multiple channels every 600-800 μ s. This allows characterization of the Doppler spectrum and time variability of the mobile channel for high frequency systems (up to 5.8 GHz). Historically the DSCP has been employed extensively for channel characterization of cellular and personal communications services (PCS). ITS has expanded the probe to 8 channels capable of mobile phased array or multiple input, multiple output (MIMO) measurements. Also available is a wide-bandwidth, high-frequency probe, particularly suited for high resolution requirements such as wireless local area network (LAN) applications up to 30 GHz. For a more detailed description of the measurement systems and applications, see this website: <http://flattop.its.bldrdoc.gov/rcirms/>

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Green Mountain Mesa Field Site

The main Department of Commerce Boulder Laboratories campus contains a field site used for outdoor wireless network research. The site is connected to the ITS laboratories via both fiber optic and 802.11 links. The fiber optic link is currently providing access to the ITS local area network (LAN) while the 802.11 link connects this field site to the ITS Wireless Networks Research Center (see p. 69). The site can provide six independent duplex fiber channels to the ITS lab. This allows research to be conducted over an isolated 1-mile outdoor Wi-Fi link. The fiber connectivity provides a LAN connection to the outdoor wireless router and for capability to operate remote data collection equipment. The outdoor router, located on an 80-foot tower, provides long range 802.11 links to other Commerce field sites. Currently these links provide 802.11b services and are also used for network performance testing.

The site's unique geographic location, several hundred feet above the main Department of Commerce campus, allows for the provisioning of wireless test links over a large portion of eastern Boulder county. The site is operated year round.

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Interoperability Research Laboratory (IRL) and Mobile Radio Communication Performance Measurements

ITS maintains a test capability for measuring the performance of land-mobile radio systems that comply with the Telecommunications Industry Association's TIA-102 and TIA-603 series of standards through its Interoperability Research Laboratory (IRL). The IRL also supports laboratory investigation of "interim solution" interoperability devices.

The measurement capabilities include the usual receiver and transmitter measurements such as receive sensitivity, co-channel and adjacent-channel rejection, spurious response rejection, and transmitter emissions mask. Highly accurate measurements are made possible by laboratory grade signal generators, fading simulators, spectrum and vector signal analysis tools, and an RF shielded enclosure. The lab possesses both models of TIA-102 (Project 25) capable communications system analyzers which can decode various aspects of the link control information, such as network access code, talk group identification, and status bit. Demodulated speech

samples can also be collected and scored for audio clarity using the ITU's PESQ algorithm.

The primary use for this capability is interoperability testing between TIA-102 radios of different manufacture and backward compatibility testing between TIA-102 radios and legacy FM systems. Other applications may be possible, for example, routine performance measurements or more niche applications, such as VoIP radio repeaters or baseband audio interoperability devices. This capability is available on a first-come, first-served basis by both NTIA and other agencies.

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ITS Internet Services

ITS provides public Internet access to NTIA/ITS publications, program information, meeting information, and on-line resources such as Telecommunications Analysis Services which are used by other Federal agencies, research partners, and private industry. Restricted-access services including electronic mail lists are used to facilitate communications with project sponsors and partners, and to support various standards committees. Some highlights of ITS Internet Services include:

- Information about ITS programs and projects. Available at <http://www.its.bldrdoc.gov/home/projects.html>
- An ITS organization chart and a complete listing of ITS staff with contact information. Available at <http://www.its.bldrdoc.gov/home/organization.html>
- Recent ITS publications including NTIA Reports, special publications, and journal articles. Available at <http://www.its.bldrdoc.gov/pub/pubs.html>
- Radio propagation data. Available at http://www.its.bldrdoc.gov/home/data/radio_propagation_data/
- Radio propagation software. Available at <http://www.its.bldrdoc.gov/home/software/>
- Telecommunications Analysis Services. Available at <http://www.its.bldrdoc.gov/tas/>
- Video Quality Metric Software. Available at <http://www.its.bldrdoc.gov/n3/video/vqmssoftware.htm>
- Information about ITS-sponsored events such as ISART. Available at <http://www.its.bldrdoc.gov/home/conferences/>
- Anonymous FTP distribution of some ITS developed software programs. Available at <ftp.its.bldrdoc.gov>

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ITS home page: <http://www.its.bldrdoc.gov>

ITS Local Area Network

ITS maintains a highly flexible local area network (LAN) to support intranetworking services and laboratory interconnection. A structured cabling system interconnects all offices and laboratories with both optical fiber and Category 5 twisted-pair cabling to support high-bandwidth communications on demand. Over 200 devices are supported on 10Base-T and 100Base-TX Ethernet segments. Connections can also be made to laboratory test beds featuring synchronous optical network/asynchronous transfer mode (SONET/ATM). This provides ITS with great flexibility and rapid reconfiguration capability for new programmatic needs.

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Mobile Radio Propagation Measurement Facilities

ITS maintains a measurement vehicle capable of radio channel characterization over a wide frequency range. The vehicle is equipped with on-board power, a telescoping mast, azimuth and elevation controllers, and global positioning system (GPS) devices with dead-reckoning backup. A suite of measurement equipment is also available for use in this vehicle. This includes wideband systems for measuring radio channel impulse response from 450 MHz to 30 GHz. Impulse response measurement capability at 30 GHz with 2ns resolution has been enhanced with the addition of a digital wideband recording system. ITS has increased its mobile channel measurement capability with the addition of an 8-channel receiver and an 8-channel 14-bit data acquisition system. Multi-channel synchronous acquisition can be used for antenna array measurements or multi-frequency broadband measurements. Mobile measurement capability allows space division multiple access (SDMA) algorithms to be studied using data collected in typical mobile environments. This data can then be used to simulate and model radio systems.

A suite of measurement software is maintained for calculating mobile propagation metrics from the impulse response data. Typical metrics are power delay profiles, delay spread, received power versus bandwidth, Doppler spectrum and coherence bandwidth.

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Pulsed CW Radar Target Generator

The Pulsed Continuous Wave (CW) Radar Target Generator is an electronic tool used to produce targets on a radar screen. The generator produces signals that simulate the returns that would normally be seen by a radar from targets in the environment. The signals are injected into the radar's receiver at the normal frequency of operation. Several parameters of the signals can be adjusted over a wide range to be compatible with several different radar models. For the same model radar, the number of targets and the range to the targets can be adjusted. Other adjustments include the displayed bearing of the targets and whether the targets are stationary or moving along concentric circular paths. Compensation adjustments can be made for radars that have large tolerances in their operating specifications. The generator can be used to verify operation or troubleshoot the radar under test. ITS uses the generator to provide simulated desired signals in interference studies where interference is injected into the radar and the effect on the targets is recorded.

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Radio Noise Measurement System

The ITS radio noise measurement system hardware consists of an omnidirectional antenna mounted on a ground plane, preselector filter, low noise preamplifier, off-the-shelf spectrum analyzer, digitizer, and computer. Noise samples are digitized prior to spectrum analyzer detection, just after spectrum analyzer log amplification. Spectrum analyzer demodulation circuits are used for aural noise identification during measurements. The measurement system noise figure is nominally 2 dB above the theoretical noise floor. Noise is measurable approximately 15 dB below and 60 dB above system noise.

The noise measurement system uses custom data acquisition software written and maintained at ITS. The software graphical user interface allows the user to customize and notate each measurement. It also displays noise samples and their corresponding first-order statistics. The statistics are revealed through an amplitude probability distribution (APD). The APD is plotted on a Rayleigh graph where the Gaussian noise appears as a straight line with a negative slope. Non-Gaussian noise is easily identified during measurements as a deviation from the straight line or a change in slope. Non-Gaussian noise exists throughout the radio spectrum.

ITS has used the noise measurement system to measure noise at 137.5 MHz, 402.5 MHz, and 761.0 MHz. The system can also be used to measure noise at higher frequencies, e.g., at 2.4 GHz in spectrum occupied by unlicensed Part 15 low power communication devices such as wireless local area networks and Part 18 industrial, scientific, and medical (ISM) devices such as microwave ovens.

The noise measurement system can be run from a building or a measurement van. A direct current converter with noise suppressor is used to power the van-mounted equipment if 120 V alternating current is not available. Calibration measurements in radio quiet zones have shown that noise contributed by the noise measurement system and power conversion equipment is negligible.

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Radio Spectrum Measurement System (RSMS)

The ITS Radio Spectrum Measurement System (RSMS) is a state-of-the-art measurement system designed for gathering information regarding spectrum occupancy, equipment compliance, electromagnetic compatibility, and interference resolution. Its purpose is to provide NTIA's Office of Spectrum Management (OSM) with critical measurement support from ITS for determining policies regarding government radio systems and spectrum utilization. RSMS is a dynamic and flexible system that incorporates automated, semi-automated, and manual techniques for the measurement and analysis of radio emissions. While not defined by any single hardware configuration, the system includes such devices as the latest in spectrum analyzers, digital oscilloscopes, vector signal analyzers, and signal detection devices. Measurements can take place in a laboratory or in the field, or they can be mobile or stationary; therefore the system has been made flexible enough to accommodate each of these situations.

An integral part of the system is the measurement vehicle, which is now in its 4th generation. The vehicle has a highly shielded enclosure (60 dB) with three equipment racks, three 10 meter masts, a 20 kWatt diesel generator, as well as Internet connections, fiberoptic control lines, multiple power outlets, and overhead cable racks. The control and acquisition software is fully developed by ITS so that new and innovative measurement techniques can be easily altered to meet the immediate needs.

A major objective in the development of the 4th generation software has been to provide a tool that can easily accommodate new equipment and different hardware configurations, and to expand on existing measurement capabilities.

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SIPRNET Capability

ITS maintains a connection to the Secret Internet Protocol Routable Network (SIPRNET). This connection allows ITS sponsors and Department of Defense users direct access to ITS tools and facilities in a secure environment, improving the quality of support that the Institute can give organizations with classified needs. Since many of the planning and associated support activities of the military require a classified channel for discussions and data transfer, the need exists for a secure environment within which project planning and support can be carried on without interruption. ITS maintains several computer systems with a variety of software capabilities to support propagation planning and modeling, as well as emerging technologies research. The secure facilities allow users to import data from many military facilities and support organizations into propagation models and other management software. A complete end-to-end propagation planning capability in a secure environment is available for classified needs. Various research studies that ITS conducts (that are determined as classified information) can also reside on the SIPRNET, allowing access by agencies on a need to know basis.

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Spectrum Compatibility Test and Measurement Sets

The introduction of new radio technologies in close physical and frequency proximity to older ones can result in electromagnetic compatibility (EMC) problems. Although theoretical models and simulations provide much useful information in guiding design decisions, the complexity of modern systems and the existing spectral environment often requires real-world measurements of a proposed system's effects within its proposed operating environment to determine its impact on other users of the radio spectrum. Another problem is the production of a controlled interfering signal with known characteristics in environments where the suspected interferer may be

unavailable for use. This includes situations such as laboratory tests using interference from ship or aircraft mounted radars or communications systems. In both situations a system is needed that simulates the spectral emissions of other devices with a wide range of latitude. Examples include determining the thresholds at which types of interference from communication transmitters are manifested as interference effects in radar receivers, and testing the response of a dynamic frequency selection wireless communication device to detect types of radar energy without actually setting up real radars for the test.

To meet these needs, ITS engineers have developed two different types of interference generators. The first is the Broadband Arbitrary Waveform Transmitter (BAWT) that is used to simulate the spectral output of a wide variety of communication systems. These signals can be coupled directly into a system under test or they can be transmitted into a target system's antenna to more accurately gauge its response to a real interference situation.

In cases where ITS can gain access to the emissions from a particular transmitter, the transmitter's emissions can be digitized using high-speed samplers. The digitized waveforms (in bandwidths up to 30 MHz and at frequencies as high as 26 GHz) are stored. The amplitudes, frequency components, and phase components of the signals are recorded for later playback by arbitrary waveform generators and selected RF signal generators. The advantage of this arrangement is that very complex waveforms may be replicated with complete confidence in the fidelity of the simulated signal to the characteristics of the original signal from which it has been derived.

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Table Mountain sign on Highway 36 (photo by J.D. Ewan).

Table Mountain Field Site and Radio Quiet Zone

Established in 1954, the Table Mountain Field Site and Radio Quiet Zone is a unique radio research facility. Located north of Boulder, the site extends approximately 2.5 miles north-south by 1.5 miles east-west, and has an area of approximately 1,800 acres. The site is designated as a Radio Quiet Zone where the magnitude of strong, external signals is restricted by State law and Federal Regulation to minimize radio-frequency interference to sensitive research projects. Facilities at the Table Mountain site include:

- **Spectrum Research Laboratory** — A state-of-the-art facility for research into radio spectrum usage and occupancy. Radio Quiet restrictions ensure that no signal incident on the mesa overpowers any other, and an antenna farm provides both directional and non-directional antennas spanning a broad range of frequencies.
- **Open Field Radio Test Site** — A flat-topped butte with uniform 2% slope, Table Mountain is uniquely suited for radio experiments. It has no perimeter obstructions and the ground is relatively homogeneous. This facilitates studying outdoor radiation patterns from bare antennas or antennas mounted on structures.
- **Mobile Test Vehicles** — There are several mobile test equipment platforms available at the mesa, ranging from 4-wheel drive trucks to full-featured mobile laboratories.
- **Large Turntable** — A 10.4-meter (34-foot) diameter rotatable steel table mounted flush with the ground. Laboratory space underneath houses test instrumentation as well as the new control equipment and motors to rotate the turntable. This facility can be operated remotely by computer.
- **18.3 Meter (60 Foot) Parabolic Dish Antennas** — These two antennas are steerable in both azimuth and elevation and have been used at frequencies from 400 MHz to 6 GHz.
- **Radar Test Range** — A large space just south of the Spectrum Research Laboratory is available for testing radar systems.

The Table Mountain Research program supports a number of research activities, e.g., studying the effects of radio propagation on the integrity of digital signal transmission and video quality, environmental and man-made noise, verification of antenna propagation models, and the development of measurement methods needed to assess efficient spectrum occupancy and usage (see pp. 10-11).

Partnerships and cooperative research activities are encouraged at the site. Other organizations currently using the facilities include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the Deep Space Exploration Society, and Coherent Technologies.

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Telecommunications Analysis Services

Telecommunications Analysis Services (TA Services) provides the latest engineering models and research data developed by ITS to industry and other Government agencies via a web-based interface (<http://flattop.its.bldrdoc.gov>). Designed to be both user-friendly and efficient, it offers a broad range of programs that allow the user to design or analyze the performance of telecommunications systems. Currently available are: on-line terrain data with 1-arc-second (30 m) for CONUS and 3-arc-second (90 m) resolution for much of the world, and GLOBE (Global Land One-km Base Elevation) data for the entire world; 2000 census data, 1990 census data (also 1997 updated); Federal Communications Commission (FCC) databases; and geographic information systems (GIS) databases (ARCINFO). TA Services has developed models that predict communication system coverage and interference for many broadcast applications. New models in the GIS environment for personal communications services (PCS) and Local Multipoint Distribution Services (LMDS) have been developed (see Telecommunications Analysis Services, pp. 36-37). The TA Services computer has about 210 GB of storage capacity.

The following is a brief description of some programs available through TA Services.

HAAT – Calculates Height Above Average Terrain for an antenna at a specified location.

PCS/LMDS – Allows the user to create or import surfaces which may include terrain, buildings, vegetation, and other obstructions in order to perform line of sight (LOS) and diffraction studies.

FCCFIND, FMFIND, TVFIND, AMFIND, and TOWERFIND – Allows the user to search the FCC database for particular stations or by search radius around a point of interest.

PROFILE – Extracts path profiles according to user-specified input parameters. After the data is extracted, either the individual elevations or an average elevation along the profile can be obtained. A user can also receive plots of the profiles adjusted for various K factors. For microwave links, Fresnel zone clearance can be determined so that poor paths can be eliminated from a planned circuit or network.

SHADOW – Plots the radio LOS regions around a specified location in the United States using digitized topographic data. The program shows areas that are LOS to the base of the antenna, areas that are LOS to the top of the antenna, and areas that are beyond LOS to the antenna.

TERRAIN – Plots terrain elevation contours from any of the terrain databases available (1-arc-second SDTS for CONUS, 3-arc-second USGS, and GLOBE for the whole world).

COVERAGE – Calculates the received signal levels along radials that are spaced at user-defined intervals of bearing around the transmitter. The program lists the contours of signal coverage of the transmitter along each radial and lists distances to user-specified contours for each radial. Either the FCC broadcast rules or the ITS Irregular Terrain Model can be chosen for calculations.

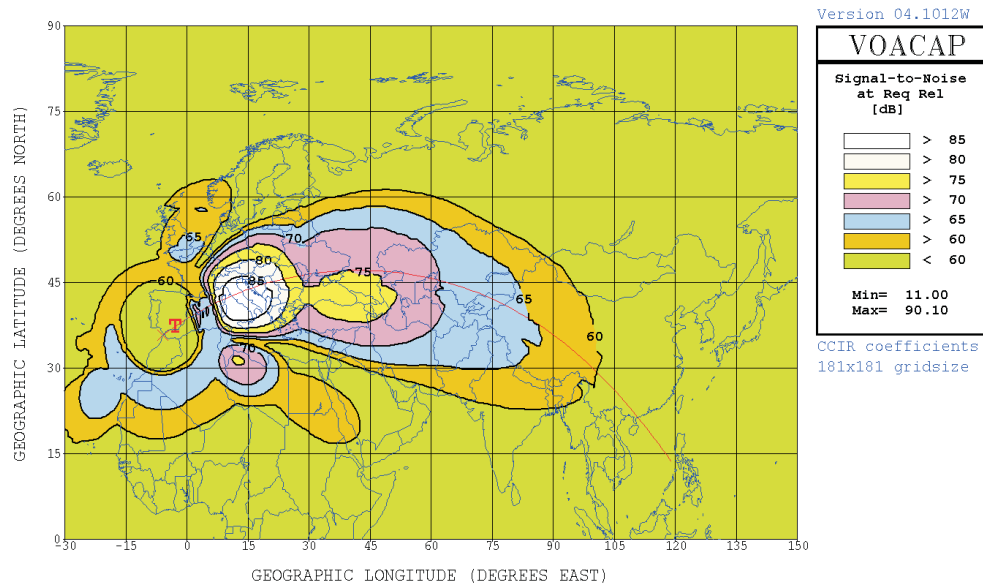
CSPM – Determines the system performance of mobile and broadcast systems in detailed output plots of signal intensity, as shown in the figure. Plotted outputs can be faxed to the user, plotted on clear plastic for overlaying on geopolitical maps, or downloaded to the user site (in HPGL, GIF, or TARGA format). This program uses the ITS Irregular Terrain Model in a point-to-point mode, or other user-chosen algorithms for path loss calculation.

HDTV – Allows the user to analyze interference scenarios for proposed digital television (DTV) stations. The model contains current FCC and MSTV allotment tables and maintains the catalogs created by all program users. The user can create new stations by hand, or by importing station information directly from the FCC database. Analyses may be performed using existing FCC database and allotment assignments, or the user can replace a station with one created and maintained in his/her catalog.

NWS – A specialized application to assist the National Weather Service in maintaining its catalog of weather radio stations (currently about 920).

PBS – An analysis model similar to the HDTV model, but specialized for Public Broadcasting

TANGIER, Morocco [HR 4/4/.5] 500kW 57deg 18ut 11.850MHz Jun 100ssn
 Tx location to grid of Rx SNRxx
 AREADATA\DEFAULT\DEF_181.V31



Example of VOACAP HF area coverage prediction.

Stations (PBS). Typical outputs may consist of composite plots showing Grade A and B coverage of several stations or “overlap” plots which show areas covered by more than one station.

ICEPAC/VOACAP/REC533 – High Frequency prediction models which can be downloaded (free) and executed on Windows based platforms.

ITM – Source code available for the Irregular Terrain Model (Longley/Rice).

IF-77 – Source code available for the IF-77 Air/Ground, Air/Air, Ground/Satellite prediction software (.1 to 20 GHz).

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Wireless Networks Research Center (WNRC)

The Wireless Networks Research Center (WNRC) provides a common laboratory area for research in the areas of wireless networks and wireless network access technologies. The WNRC allows the Institute to consolidate efforts in several areas, such as the RF/network interface. This work uses RF link characterization correlated with low-level network management protocols to develop PCS-to-PCS interference models, wireless network propagation models,

non-cooperative wireless measurement, and wireless network discovery. RF/network interface measurement devices are used to make detailed measurements of PCS and cellular networks. One device uses a series of PCS/cellular phones to extract low-level protocol messages, network management information, and RF signal quality parameters. Another device has the ability to perform provider-independent PN offset scans and cdma2000 level 3 message logging.

The WNRC contains an experimental IEEE 802.11b wireless local area network (WLAN). ITS has conducted a series of wireless Voice over IP (VoIP) tests utilizing this infrastructure. The WLAN resources include IP packet logging equipment that can be used in network measurements. ITS has added a code domain analyzer (CDA) measurement capability to the WNRC. The CDA is used to collect both short and long term Walsh channel data for any target IS-95 base station. The CDA operates in both the cellular and PCS frequency bands and can be used in fixed or mobile environments.

The WNRC is used to conduct ITS work in the area of inter-PCS interference, in support of TIA TR-46.2. ITS also has the capability to simulate PCS interference using a series of ITS implemented interference models.

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